SCR Catalyst Performance on U.S. Coal Fired Boilers

Julie Crowe. Presenter
Hitachi Zosen Engineering U.S.A. Ltd., 10777 Westheimer Road, Suite 1075, Houston, TX, 77042
E-mail: crowe@hzusa.com; Telephone: (713) 532-9611; Fax: (713) 532-9533

Masayoshi Ichiki. Co-author
Hitachi Zosen Corporation, 2-11, Funamachi, 2-chome, Taisho-ku, Osaka 551-0022, Japan
E-mail: ichiki@hitachizosen.co.jp. Telephone: 011-81-6-6551-9682; Fax: 011-81-6-6551-9906

Summary

Environmental regulations have tightened up during recent years in the U.S., requiring low nitrogen oxides ($NO+NO_2$) emissions from all kinds of furnaces, particularly coal fired boilers, because of the large amounts of NOx generated. It is recognized that Selective Catalytic Reduction (SCR) is the most available control technology to achieve the required reduction of NOx in the flue gas. This technology uses a catalyst and ammonia (NH_3) as a reagent for conversion of NOx to nitrogen (N_2) and water (H_2O).

SCR applied to coal fired boilers has been successfully operated in more than 30 units representing a total of 14,300 MW in Japan, where only dry bottom boilers fired by imported bituminous coal are used. However, in the U.S. there are some wet bottom boilers and many dry bottom boilers fired by sub-bituminous coals, especially Powder River Basin (PRB) coal. Therefore, we looked at the influence of contaminants from these coals using the fly ash contained in flue gas from U.S. boilers and compared it to those coals being used in Japan. We found that wet bottom boilers with fly ash recirculation have high levels of gaseous arsenic (As_2O_3) in the flue gas and that dry bottom boilers fired by PRB coal have high contents of calcium (Ca) in the fly ash. These results show high fouling indexes compared with dry bottom boilers in Japan.

Based on the analysis of coals and fly ash properties in U.S. boilers, we investigated the influences of gaseous arsenic from wet bottom boilers, fly ash from PRB coal fired boilers, and acid gases from high sulfur coal fired boilers on SCR catalyst performance including deactivation, plugging and erosion due to fly ash. The tests were conducted using a corrugated ceramic honeycomb structural catalyst that consists of TiO_2-V-W.

The test results showed the following:

(1) The catalyst is drastically deactivated by gaseous arsenic, and the deactivation rate (K/K_0) corresponds to the amount of arsenic accumulated in the catalyst (As/TiO_2). As a matter of course, the deactivation equation is established.

(2) The catalyst exposed to fly ash from PRB coal fired boilers at 660°F also deactivates, probably caused by alkali metals (K, Na, Ca) deposition on the catalyst. The deactivation rate corresponds to the amount of alkali metals transferred to the catalyst from the fly ash.

(3) On the condition that no dewing occurs in the ash layer on the catalyst, the deactivation rate is stable to about 0.8 when the catalyst is exposed to fly ash from PRB coal, which is similar to the deactivation tendency of bituminous coal. However, the deactivation rate is accelerated at startup and during long term shutdown, which simulates the wet condition where dewing occurs. A coating of inorganic compounds can be applied to the catalyst to help reduce the deactivation by alkaline metals deposition.

(4) The catalyst is also deactivated by sulfur trioxide (SO_3) in the flue gas at low temperatures, but this deactivation is reversible and the catalyst activity can be recovered by raising the temperature to 660°F at a composition of flue gas similar to that from high sulfur bituminous coal fired boilers. No influence on catalyst activity is found for HCl gas up to 1,500 ppm.

(5) The fly ash from PRB coal accumulates on the catalyst surface at low flue gas velocities, but can easily be removed by soot blowing.

(6) The catalyst with edge-hardened treatment is very effective in avoiding erosion by fly ash. No erosion was found upon using fly ash with an average particle size of 100 microns for a period equivalent to more than 15,000 hours of operation.

Based on operating experience with SCR on dry bottom boilers fired by bituminous coal including high sulfur coal, there is no difference in catalyst activity and SO_2 to SO_3 oxidation rate between the boilers in Japan and the U.S., for up to 16,000 hours operation without soot blowing.

Taking into account our comparison results between U.S. and Japan, the issues that need to be considered with regards to SCR catalyst in applications to U.S. coal fired boilers are as follows:

(1) For dry bottom boilers fired by bituminous high sulfur coal in the U.S., countermeasures to catalyst deactivation can be taken similar to those used in Japan. These include using a catalyst that exhibits low SO_2 oxidation and high resistance to fly ash erosion, and is free of plugging. Also, special precautions should be taken to avoid deactivation of the catalyst by deposition of fly ash on the catalyst surface during startup and long term shutdown of the boiler.
(2) For dry bottom boilers fired by PRB coal, a catalyst surface coating is effective to minimize deactivation by fly ash, and soot blowing devices are required to prevent fly ash accumulation on the catalyst at low flue gas velocities. These are additional countermeasures that should be taken over those applied to bituminous firing boilers.
(3) For wet bottom boilers, especially with fly ash recirculation, the catalyst deactivation rate can be estimated corresponding to the catalyst life required and the gaseous arsenic concentration at the inlet of the catalyst. Determination of catalyst specifications and a catalyst life management plan are necessary due to serious deactivation.